Morphologie 109 (2025) 100922

Disponible en ligne sur
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com

ORIGINAL ARTICLE

The level of confidence of dentists in identifying intact and sectioned teeth

S. Mânica [a,*], H. Pandey [a], G. Mânica [a], R. Qaq [a], C. Capitaneanu [a,c], E. Nuzzolese [d], C. Shields [b], R. Boyle [b], R. Merdietio Boedi [e]

[a] *Centre for Forensic and Legal Medicine and Dentistry, University of Dundee, School of Dentistry, Level 7, Dundee, DD1 4HN Scotland, UK*
[b] *School of Dentistry, University of Dundee, Nethergate, School of Dentistry, Dundee, DD1 4HN Scotland, UK*
[c] *Centro de Investigación en Odontologia Legal y Forense, Faculty of Dentistry, Universidad de La Frontera, Temuco 4780000, Chile*
[d] *Section of Legal Medicine, Department of Public Health and Paediatric Sciences, University of Turin, Turin, Italy*
[e] *Department of Dentistry, Faculty of Medicine, Universitas Diponegoro, Semarang, Central Java, Indonesia*

Disponible sur Internet le 7 November 2024

KEYWORDS
Forensics ;
Morphology ;
Anatomy ;
Confidence ;
Dentistry ;
Forensic dentistry

Summary
Objective. — This study aimed to assess the confidence levels of dentists in identifying intact and sectioned human teeth and to identify the factors contributing to variations in confidence levels.
Design. — An anonymous Jisc e-survey showing 14 questions was sent to dentists worldwide. Apart from acquiring demographic details of the participants, ten three-dimensional (3D) tooth models were presented for tooth identification including the opinion on the level of confidence in identifying. They included seven permanent and three deciduous teeth in intact or sectioned state. The tooth models were created and manipulated using ZBrush software (Maxon Industries, Inc.) and uploaded to the Sketchfab model hosting platform. The accuracy of results was quantitatively analysed in five categories, namely: (I) tooth type, (II) region, (III) tooth classification, (IV) tooth within the same class, and (V) FDI World Dental Federation notation.
Results. — Most participants received education in dental anatomy at the undergraduate level. No significant differences in accuracy were seen between intact and fractured tooth models. The highest accuracy was seen in Category I (Permanent or Deciduous, 0.74) and the lowest in Category V (FDI Notation, 0.26). The perceived confidence of each participant (total of 56) was seen to have the highest accuracy when the participant opined limited confidence, although with no significant differences for each category ($P > 0.05$). Moreover, the most common error was found in the category II region, where participants could not correctly locate the tooth on the right or left side of the mouth in six 3D tooth models.

* Corresponding author. Centre for Forensic and Legal Medicine and Dentistry, University of Dundee, 2 Park Pl, Dundee DD1 4HR, Dundee, Scotland, UK.
Adresse e-mail : s.manica@dundee.ac.uk (S. Mânica).

https://doi.org/10.1016/j.morpho.2024.100922

Conclusion. — The assessment of intact and sectioned teeth has not presented differences in accuracy. High accuracy was seen when dentists categorised permanent and deciduous teeth. The highest accuracy in results was linked to the limited confidence of dentists but factors contributing to this level of confidence are not clear in this study. More attention should be paid to the dental features that distinguish location on the right or left side of the mouth.

Introduction

The ability to accurately restore the anatomy of a tooth is a fundamental skill for dental professionals. They should have a good understanding of the tooth characteristics, similarities, differences, and variations of teeth [1]. Those skills are crucial for routine dental practice and also for forensic odontology, where teeth, both intact and sectioned, can provide vital evidence in identifying individuals in criminal investigations and mass disaster operations. Dental anthropologists are also concerned with the analyses, recording, and interpretation of anatomical crown and root traits, which are valuable for the study of human variations as well as for fields such as archaeology and palaeontology [2], comparative odontology (zoology) and osteoarchaeology [3].

Even though teeth are stable over time, being resilient to high temperature, trauma, and variations in humidity and pressure [4,5], they might be presented in the form of isolated teeth or tooth fragments as a result of mass fatalities. For this reason, forensic dentists must master precise knowledge of dental anatomy and morphology [6,7]. The recovery of bodies found in shallow earth graves or resting on earth should be careful to avoid missing loose teeth, fragments, or restorations. When bodies are recovered from water it is not always possible to retrieve an intact tooth [8]. In dental anthropology, the study of extensive tooth wear in teeth from past generations is attributed mostly to functional demands, such as the chewing of food and the use of teeth as tools [9].

It is understood that dental anatomy education is thoroughly provided to dental professionals in the early years of qualification and the focus becomes more on the clinical aspects of dentistry in their practice [10]. In terms of clinical significance, dental professionals must follow the tooth anatomy in abraded teeth to create a functionally more efficient restoration and lessen the load on the teeth [11]. The relationships of tooth form to the form of the supporting structures, including the gingiva must also be considered [12]. Moreover, dentists are required to visualise the dental anatomy from radiographs and cone beam computed tomography (CBCT) scans [13] for diagnosis.

Confidence levels in Dentistry have been explored in the past. A study showed that higher confidence levels were demonstrated by final-year dental students for clinical information gathering, diagnosis, and management planning [14]. Complex procedures that were least practiced scored the lowest in overall mean confidence [15]. Different types of procedures would also change the level of confidence. Students felt more confident in direct restorations and simple endodontic treatment as opposed to indirect restorations and complex endodontic treatment [16]. Confidence of postgraduate dentists following a prolonged period of study needs to be explored [17].

Even though much has changed in dental anatomy training with the creation of three-dimensional tooth morphology educational tools [1,18,19], not many studies have investigated the confidence levels of dentists in tooth morphology. Results of a study that investigated the knowledge, attitude, and practice of tooth morphology were significantly different among undergraduates and postgraduate students. The prior might show a lack of self-confidence because of less clinical exposure, while the latter might develop better psychomotor skills due to higher clinical exposure and adopt self-directed learning principles [20].

The factors that affect confidence in tooth identification are unknown. It should be investigated whether dentists could have their confidence more challenged by the distinction between permanent or deciduous teeth or locating the tooth in the correct quadrant of the mouth. Additionally, the degree of difficulty when identifying teeth presenting different damages (missing tissues because of physical, chemical, or pathological causes) should be understood. For this reason, this study aimed to assess the confidence levels of dentists in identifying various intact and sectioned human teeth and the contributing factors to variations in confidence levels.

Material and method

An anonymous e-survey was created using Jisc online surveys v3 and sent by email to several dentists who are members of the Indo-Pacific Academy of Forensic Odontology, Association Forensic Odontology for Human Rights (AFOHR), and Dentistry World Update group. It was divided into two parts, part one (P1) being about participant demographic details and composed of three closed-ended questions (Q1—Q3): Q1 — *What is your profession?** Dentist; Dentist (in postgraduate training in Dentistry); Dentist (have completed postgraduate training in Dentistry); Q2 — *Please choose the description below that best describes your level of expertise in dental anatomy or tooth identification*:* I have received teaching in dental anatomy or tooth identification (at the undergraduate level only); I have received enhanced/additional training in dental anatomy or tooth identification (beyond undergraduate level); I have received enhanced/additional training in dental anatomy or tooth identification (beyond undergraduate level) and I have taught others about dental anatomy or tooth identification; I have taught others about dental anatomy or tooth identification; Other; Q3 — *If you answered 'other' above, please specify*.

The second part (P2) showed eleven questions (Q4—Q14) presenting 3D tooth models for tooth identification. The models were produced by a medical illustrator using ZBrush software (Maxon Industries, Inc.) and manipulated so that some of the teeth were sectioned longitudinally, axially, or transversally (final models were either intact, sectioned to remove the root/part of the root, sectioned to remove the crown/part of the crown, or sectioned longitudinally to remove part of both root and crown). The resulting 3D models were renamed to remove all references to which tooth they represented and then uploaded to Sketchfab 3D model hosting platform. The 'cut' surfaces of the models were flat, white surfaces (i.e. no internal structure of the tooth was shown).

The tooth or tooth fragment was shown alongside a ruler X mm in length, for scale within each question page. The participant would also click on 'View Model N1, N2, N3... etc.' to inspect each tooth in 3D. Each model was identified only by a code number: ''Model N1'', ''Model N2'', ''Model N3'' as seen in Table 1 and participants could rotate and zoom the model using the 3D controls. For each tooth, sub-questions (SQa — SQc) were presented as follows: SQa — *Please attempt to identify the above tooth according to the FDI system* (all permanent and deciduous teeth are listed in the dropdown menu below); (Deciduous, permanent, I could not identify this tooth); SQb — *Please state your level of confidence in identifying the previous tooth according to the following range*: 1 (tooth identified with total confidence); 2 (tooth identified with limited confidence); 3 (tooth identified with low confidence); 4 (tooth identified with no confidence); 5 (impossible to identify tooth, confidence can't be scored). Experimentation on specimens or subjects has not happened in this study so ethical approval was not required.

The resulting questionnaire was analysed for accuracy in five categories, namely: (I) tooth type (i.e., permanent or deciduous), (II) region (e.g., region 1 for upper right permanent, region 2 for upper left permanent, region 5 for upper right deciduous, and so on), (III) tooth classification (i.e., incisors, canines, premolars, or molars), (IV) tooth within the same class (e.g., upper central permanent incisor, upper lateral permanent incisor, and so on), and (V) FDI Notation (e.g., 11, 12, 23). The resulting accuracy was further compared using a *t*-test between the fractured and intact teeth in the questionnaire, and ANOVA analysis to test the difference of accuracy for each perceived confidence. To simplify the calculation, mean confidence was used to derive the overall perceived confidence of the respondent. This mean confidence was calculated by converting the confidence level for each question to a number (i.e., total confidence = 1, limited confidence = 2, etc.), sum the overall number, and then converting it back to the confidence level based on the score times 10 (i.e., sum of Confidence Score 10 = total confidence, 11—19 = limited confidence, etc.).

Accuracy is derived from the total correct responses for each question, divided by the number of questions if necessary (i.e., accuracy for intact tooth questions will be divided by four, and accuracy for fractured tooth questions will be divided by six). Further analysis using Fleiss Kappa was calculated for inter-observer agreement to observe the consistency of answers between participants. All analyses were conducted in RStudio. Finally, if discrepancies were found in the answers for the identification of each tooth model, the two most popular answers would be compared by categorizing the error according to the category (I—V).

Results

A total of 56 participants took part in the study, with most of the participants being *dentists* who had received education in dental anatomy *only at the undergraduate level* ($n = 13$). Groups with the second highest number of participants were *dentists in PG training* who had received education in dental anatomy *only at the undergraduate level* and *dentists with PG training* with *additional training and taught others* ($n = 7$ each) as shown in Fig. 1.

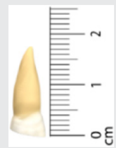
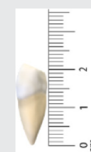
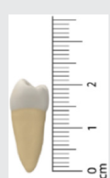
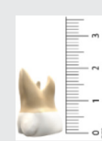
Fig. 2 reports the overall accuracy analysis and Kappa values for each category (I—V). Results for accuracy: category I, tooth type (permanent or deciduous; 0.74) showed the highest accuracy whilst the lowest accuracy was seen in Category V (FDI Notation; 0.26). The more dentists were challenged, the lower the accuracy. Additionally, the Kappa values ranged from 0.19 (category V; FDI notation) to 0.625 (category III; incisors, canines, premolars, or molars).

Most participants incorrectly identified more than half of the models (N2, N5, N6, N7, N8, and N9). More errors were seen in category II, region. Participants could not correctly locate the tooth on the right or left side of the mouth in the assessment of six models. Errors in category I, tooth type (permanent or deciduous), and category IV, (tooth within the same class) were also registered as seen in Table 2.

Table 3 shows the *t*-test accuracy analysis to note significant differences between intact and fractured 3D tooth models for each category (I—V). Significant differences were seen in the mean accuracy not due to the tooth fracture status, but rather whether the tooth was deciduous or permanent (four variables).

Additionally, the difference in accuracy for each perceived confidence [1 (tooth identified with total confidence); 2 (tooth identified with limited confidence); 3 (tooth identified with low confidence); 4 (tooth identified with no confidence); 5 (impossible to identify tooth, confidence can't be scored)] was assessed. The perceived confidence of participants was seen to have the highest accuracy when participants opined ''limited confidence'', although with no significant differences for each category ($P > 0.05$). Considering category I, tooth type (permanent or deciduous), most participants ($n = 12$; 21%) correctly answered 7 out of 10 tooth models presenting an overall ''limited confidence''. Results for category II, region (quadrant of the mouth), 8 participants (14%) correctly answered 3 out of 10 tooth models presenting an overall ''limited confidence''. Results for category III, tooth classification (i.e., incisors, canines, premolars, or molars), showed 12 participants (21%) correctly answering 7 out of 10 models with an overall ''limited confidence'' equal to 12 participants (21%) answering 7 out of 10 models with an overall ''low confidence''. In category IV, tooth within the same class (e.g., upper central permanent incisor or upper lateral permanent incisor) most of the participants ($n = 14$; 25%) have corrected answers to only half of the tooth models ($n = 5$) with an overall ''limited confidence''. Considering category V, FDI Notation (e.g., 11, 12, 23), most participants ($n = 11$; 19%) correctly answered

Table 1 Description of the ten 3D digital models followed by image with a ruler. The link to each model was provided for assessment in the survey.

Model	Permanent (P) or deciduous (D)	Intact (I) or sectioned (S)	Tooth with a ruler	Model	Permanent (P) or deciduous (D)	Intact (I) or sectioned (S)	Tooth with a ruler
Model N1 tooth 21 (length = 18 mm)	P	S Incisal edge absent		Model N6 tooth 73 (length = 17 mm)	D	S Disto-Incisal edge absent	
Model N2 tooth 36 (length = 23 mm)	P	S Distal half of crown and root absent		Model N7 tooth 18 (length = 17 mm)	P	I	
Model N3 tooth 23 (length = 27 mm)	P	I		Model N8 tooth 25 (length = 22 mm)	P	S Distal aspect of the crown, Buccal and Palatal cusp tips absent. Disto-cervical root absent	
Model N4 tooth 75 (length = 14 mm)	D	S Occlusal surface and middle 1/3rd of crown absent		Model N9 tooth 62 (length = 16 mm)	D	I	
Model N5 tooth 34 (length = 22 mm)	P	I		Model N10 tooth 26 (length = 21 mm)	P	S Occlusal surface absent	

a maximum of two models with an overall ''limited confidence''. The distribution of results is shown in Table 4.

Discussion

When evaluating the expertise level of participants, a relatively low level of expertise (i.e., only at the undergraduate level) is observed in contrast with participants presenting a relatively high level of expertise (i.e., additional training and taught others). This indicates that current results reflect more on the expertise of general dental practitioners without further training in the field. Continuing professional development (CPD) is important in the dentist's life. In the U.K., CPD and lifelong learning are key parts of the General Dental Council's (GDC) strategy for enhancing clinical governance within the dental profession [21]. In Europe, plans to build core topics into CPD requirements will ensure that all dentists have up-to-date knowledge and skills in topic areas [22].

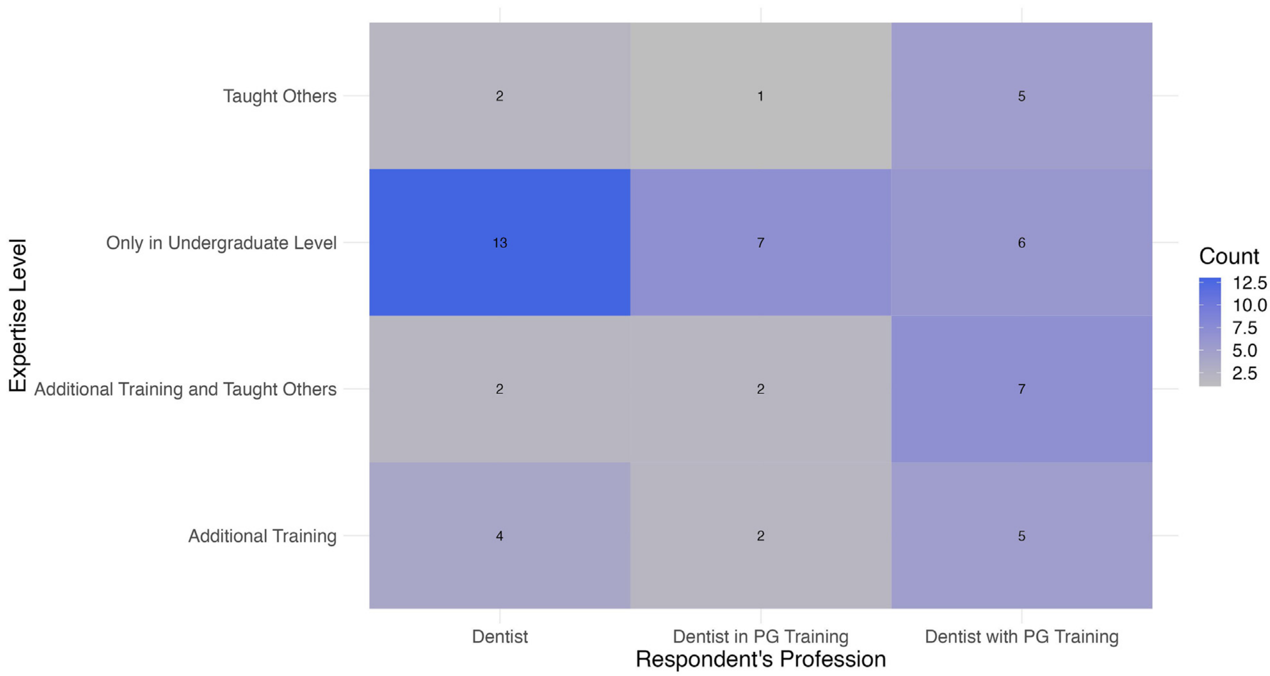


Figure 1 Sample distribution divided by respondent's profession (x-axis) and expertise level (y-axis). The shades of blue with a darker tone represent higher values.

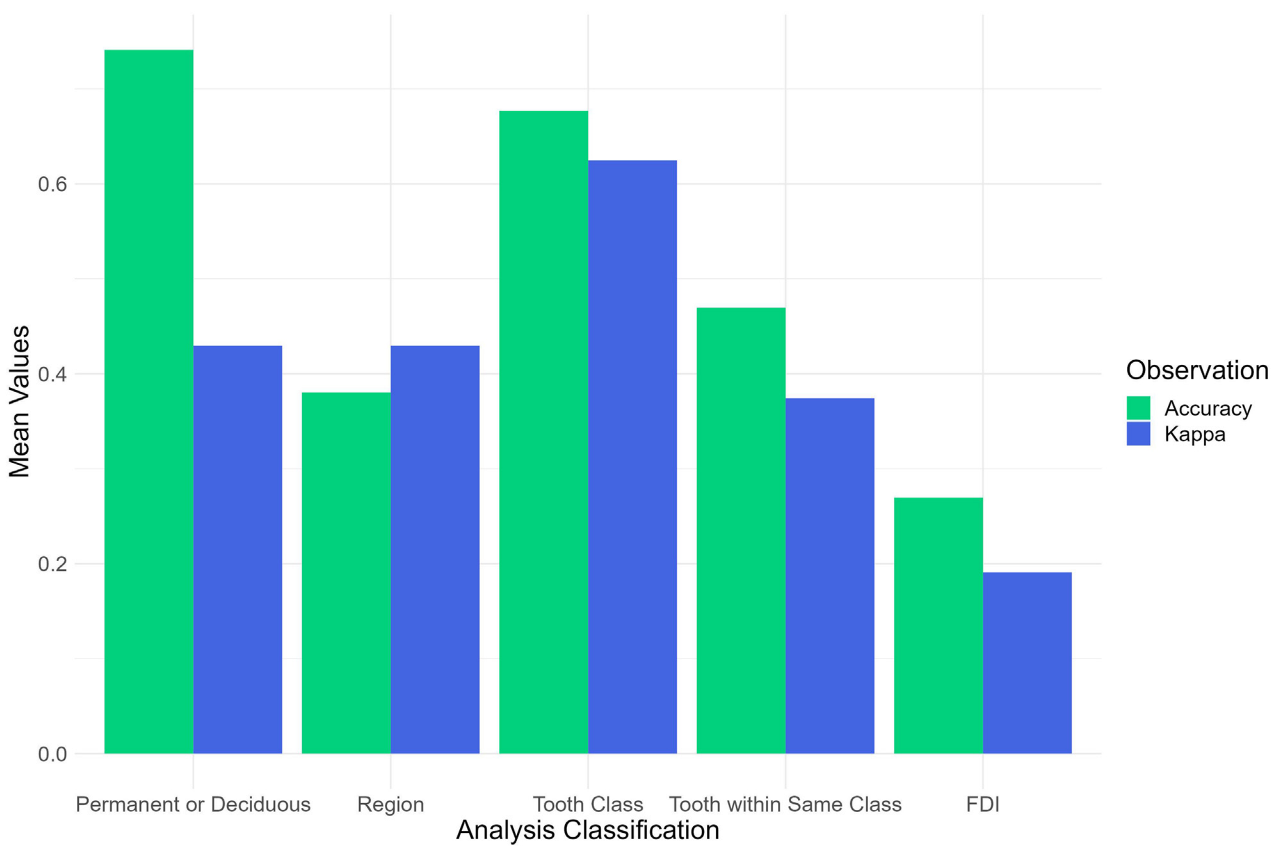


Figure 2 The mean value (y-axis) of accuracy (green) and Kappa Value agreement (blue) for each analysis classification (x-axis).

Table 2 Distribution of main answers and category of errors per model.

Model	The two most popular answers (%)	Category of error	Model	The two most popular answers (%)	Category of error
N1	46%: tooth 21[a] 30%: tooth 11[b]	Category II	N6[c]	02%: tooth 73[a] 21%: tooth 33[b]	Category I
N2[c]	19%: tooth 36[a] 26%: tooth 46[b]		N7[c]	12%: tooth 18[a] 30%: tooth 28[b]	Category II
N3	63%: tooth 23[a] 16%: tooth 13[b]		N8[c]	11%: tooth 25[a] 16%: tooth 44[b]	Categories II & IV
N4	35%: tooth 75[a] 21%: tooth 85[b]		N9[c]	12%: tooth 62[a] 54%: tooth 22[b]	Category I
N5[c]	28%: tooth 34[a] 39%: tooth 35[b]	Category IV	N10	39%: tooth 26[a] Tooth 16, tooth 64, tooth 65 (each 11%)[b]	Categories I and II

[a] Correct answers.
[b] Other most popular answers.
[c] The six models where the % of error was greater than the correct answers.

Table 3 Distribution of the results from the *t*-test accuracy analysis for each category according to four variables.

Categories	Description	Mean accuracy			
		Intact tooth	Fractured tooth	Deciduous tooth	Permanent tooth
I. Tooth type	The tooth is permanent or deciduous	0.76	0.72	0.39[a]	0.89[a]
II. Tooth region	Mouth quadrant	0.43	0.35	0.23	0.44
III. Tooth classification	Incisors, canines, premolars, or molars	0.74	0.63	0.36[a]	0.81[a]
IV. Tooth class	Tooth distinction within the same tooth class	0.48	0.46	0.26	0.55
V. FDI Notation	Tooth number	0.29	0.26	0.16	0.31

[a] Significant difference ($P < 0.05$).

Mean accuracies in various categories

Dentists were highly accurate when distinguishing permanent from deciduous teeth. To a qualified dentist, the differences in sizes, root-crown proportions, and features between permanent and deciduous teeth may be obvious and comparatively easy to assess. For instance, the crown length is relatively longer in permanent teeth when compared to deciduous teeth, while the root length is relatively shorter in permanent teeth than in deciduous teeth. Additionally, the mesiodistal crown diameter is relatively smaller in permanent teeth (MD) than in deciduous teeth [23]. Moreover, the roots of deciduous molars are more splayed than corresponding permanent roots and appear to bifurcate immediately below the cervical margin [24].

The second most accurate assessment was the tooth classification of incisors, canines, premolars, or molars. Tooth classification can be discriminated by several features such as the incisal edge of incisors, single-cusp of the biting surface of canines, two-cusps (or three) of premolars, and the wide occlusal table of molars containing three or more well-designed cusps [24]. Results from a recent study indicate that tooth identification aligns with the general cognitive process of matching visual information with prior knowledge (pattern recognition) in higher association areas to produce a semantic interpretation. Tooth contour is a parameter that is easy to match with the patterns in the brain [25]. Another study proved the importance of tooth contour locating segmentation using dental impression images for tooth identification [26].

Dentists were least successful in categorizing teeth according to the FDI Notation. This would be the most challenging classification because first, the participant must correctly classify the four previous categories (I—IV). An efficient process of human tooth identification follows five steps starting with the distinction between deciduous and permanent teeth, the distinction of tooth classes, the distinction between maxillary and mandibular teeth, identification

Table 4 Cross-tabulation between participants' confidence level and their respective correct answers out of 10 models for each category (I—V).

Category I — Permanent or deciduous

Confidence level	Score (10 models)						
	4	5	6	7[a]	8	9	10
Impossible	1	—	—	—	—	—	—
No confidence	—	1	1	—	1	—	—
Low confidence	—	3	1	6	8	3	—
Limited confidence	—	—	2	**12**	8	4	1
Total confidence	—	—	—	2	—	2	—

Category II — Tooth region

Confidence level	Score (10 models)						
	1	2	3[a]	4	5	6	7
Impossible	—	1	—	—	—	—	—
No confidence	—	—	1	2	—	—	—
Low confidence	2	4	4	5	2	4	—
Limited confidence	—	5	**8**	6	5	1	3
Total confidence	—	—	—	2	1	1	—

Category III — Tooth classification

Confidence level	Score (10 models)						
	3	4	5	6	7[a]	8	9
Impossible	—	1	—	—	—	—	—
No confidence	—	—	1	1	1	—	—
Low confidence	—	1	1	3	**12**	4	—
Limited confidence	—	3	—	6	**12**	4	3
Total confidence	—	—	—	—	2	1	1

Category IV — Tooth within the same class

Confidence level	Score (10 models)						
	2	3	4	5[a]	6	7	8
Impossible	1	—	—	—	—	—	—
No confidence	—	—	1	2	—	—	—
Low confidence	1	2	6	8	1	3	—
Limited confidence	3	2	2	**14**	2	3	1
Total confidence	—	2	—	1	1	—	—

Category V — FDI notation

Confidence level	Score (10 models)						
	0	1	2[a]	3	4	5	6
Impossible	—	1	—	—	—	—	—
No confidence	—	—	1	1	1	—	—
Low confidence	—	3	8	5	3	2	—
Limited confidence	—	3	**11**	7	4	—	2
Total confidence	1	—	—	2	—	1	—

Bold characters are maximum number of correct answers.

[a] High scores.

within the same tooth class, and finally the distinction between left and right sides of the tooth [3]. The incorrect identification of avulsed or isolated teeth will prevent forensic dentists from associating those teeth with the correct bodies presenting sockets of teeth missing postmortem. During body decomposition, teeth commonly are disassociated from their alveoli (bone) because of the disappearance of the surrounding soft tissue and the periodontal ligament that keeps the teeth attached to bone. This is true for single-rooted teeth such as incisors and canines and also holds for immature molars and premolars [27]. Human-made and natural disasters can result in severely fragmented and commingled human remains [28] and amongst those, isolated teeth. Tooth remains can also be recovered from mass graves [29]. Moreover, the correct assessment of avulsed teeth can help with the counting of the number of individuals [8].

Level of confidence

Another finding is that the most popular level of confidence of the participants was ''Limited Confidence'' which was seen as linked to the highest accuracy during the assessment. One would expect that the correct answer would come from a participant with total confidence. A factor that might have contributed might be the assessment of tooth morphology using 3D models and not the real teeth. The appreciation of dental features requires detailed analysis. It is claimed that lectures, illustrated textbooks and software programs may be helpful tools in the dental curriculum, but they cannot replace direct contact with real teeth through vision and touch [30]. Results of a comparative study in dental anatomy showed that extracted tooth was rated highest in educational value by the students while the 3D printed model was rated easiest to use [31]. Real teeth can also be replaced by artificial ones during training in dental clinics. A study on the use of artificial teeth for pre-clinical endodontic training achieved similar educational outcomes compared to extracted teeth but the experiences reported by the students diverged [32]. Moreover, recent studies presented evidence that 3D virtual tooth identification can be used to assess dental students' understanding of dental anatomy effectively [1,18]; however, this could be considered a new approach, and the participants might not have had exposure to virtual assessment as undergraduate students.

The metric analysis of tooth morphology is not less important. The genetic influence on different human tooth dimensions [33] and average sizes have been calculated in populations [34,35]. Also, deciduous teeth have a smaller size when compared to permanent teeth [24]. The assessment of the tooth size is also important during the anamnesis. Anomalies in size can be noted as macrodontia, the term used to designate teeth that are larger than normal, and microdontia where teeth are smaller in size or volume than normal [36]. This could be easily accomplished by comparing the teeth of the same individual; however, the avulsed teeth of different individuals do not permit comparison. Digital tooth models also do not offer parameters especially because models can be interactive and controlled by the user [37]. The participants of this study could see a ruler positioned against the image of the tooth module but some faced limitations.

The level of 'limited confidence' could also be slightly interpreted as a lack of total self-confidence during the assessment. On one hand, this could be associated with less clinical exposure [20,38]. On the other hand, experience and self-confidence correspond directly to the learning experiences and self-efficacy constructs [39]. The factors involving the analysis of the personality of the participants are outside the scope of this study.

Different accuracy between the fractured and intact tooth

To positively identify a tooth, a dentist relies on key anatomical landmarks. For example, observing the number and ratio of cusps can help identify an upper first molar, and comparing the size of the cusps can determine the tooth's position. Without these details, identifying the teeth becomes more challenging. The contours of the dental crowns are very informative and highly relevant to basic dental morphology. For instance, the cusps of teeth can usually be referred either to vestibular (buccal) or to oral (lingual) sides, which indicates the side of the mouth [40]. The assessment of cusps is so important that a study quantified the morphological parameters for tooth identification by assessing the angles between cusps, distances between cusps and the mesial pit of maxillary first molars, as seen in digitalised dental casts [41]. It is important to note that the morphological information provided by the dental crown can be damaged. Erupted tooth in the functional form (occlusion) can be subject to attrition (physiological or pathological) or abrasion [42].

Although our results indicated that the mean accuracy for each category was higher for intact teeth, quantitative analysis revealed no significant differences between them. This suggests that multiple anatomical variations can still be used to identify a tooth to some extent (i.e., identifying only the tooth type), but it might not be sufficient to completely identify a tooth using the FDI notation. Interestingly, a significant difference was found when respondents identified deciduous versus permanent teeth, with a higher mean accuracy in identifying primary teeth. The size is the main distinguishing factor between permanent and deciduous teeth, but other multiple anatomical differences need to be factored in. However, the variations within deciduous teeth are quite similar to each other (12), which creates a greater challenge in positively identifying a specific deciduous tooth, especially if it is fractured.

The maxillary left central incisor (model N1) presented with a missing incisal edge was identified correctly by 46% of the participants, which could be attributed to the size and shape of the visible crown and complete root assisting in the identification of the tooth region and class, the distal bend at root tip would indicate the correct side. 30% of participants incorrectly identified it as the right incisor instead. The disto-incisal edge of the deciduous mandibular left canine (model N6) was missing, 2% of the participants identified it correctly, while 21% identified it as the permanent mandibular left canine. The deciduous maxillary left lateral incisor (model N9) was intact, but it was correctly identified by only 12% of participants, while 54% of participants identified it as the permanent maxillary left lateral incisor. Previous guidelines indicated that the keys to collecting good dental morphological data are the availability of dental plaques for comparison, magnification, good lighting, caution and experience [43]. The level of confidence of participants could have been impacted by such technical factors, particularly since the study was performed using digital modules.

Moreover, in six tooth models, participants could not correctly locate the tooth on the right or left side of the mouth. Distinctions can be made by carefully assessing specific dental features such as the curvature of the cementoenamel junction (CEJ), the incisal edges of anterior teeth, the cusps ridges of posterior teeth and the correct distinction between the lingual and vestibular surfaces [24].

The limitations of the study include the small sample size of participants and the use of 3D models instead of real teeth as it is unknown if the participants were familiar with them. Some models could not be freely rotated. Further studies should be performed on real teeth and teeth fragments and include many participants with uniform distribution across different backgrounds.

Conclusion

Dentists in this study could correctly categorise permanent and deciduous teeth with high accuracy. The assessment of intact and sectioned teeth has not presented differences in accuracy. The highest accuracy in results was linked to the limited confidence of dentists but factors contributing to this level of confidence are not clear in this study. More attention should be paid to the dental features that distinguish location on the right or left side of the mouth.

Disclosure of interest

The authors declare that they have no competing interest.

Acknowledgements

We would like to thank the digital artist Emily Mc Dougall who created some of the initial 3D models with advice from Andrew Mason and Mark Roughley.

Références

[1] Overskott HL, Markholm CE, Sehic A, Khan Q. Different methods of teaching and learning dental morphology. Dentistry J 2024;12:1—12.
[2] Chowdhry A, Popli DB, Sircar K, Kapoor P. Study of twenty non-metric dental crown traits using ASUDAS system in NCR (India) population. Egypt J Forensic Sci 2023;13(1):8, http://dx.doi.org/10.1186/s41935-023-00329-2.
[3] Kondo S, Morita W, Ohshima H. The biological significance of tooth identification based on developmental and evolutional viewpoints. J Oral Biosci 2022;64(3):287—302, http://dx.doi.org/10.1016/j.job.2022.05.004.
[4] Bogin B. Patterns of human growth. In: Patterns of human growth. 3rd ed. Cambridge, UK: Cambridge University Press; 2020. p. i—ii [https://www.cambridge.org/core/product/6C3D440B3B7A730E793B5AE910EF24E5].
[5] Mânica S, Forgie A. Forensic dentistry now and in the future. Dent Update 2017;44(6):522—30, http://dx.doi.org/10.12968/denu.2017.44.6.522.
[6] Mânica S, Merdietio Boedi R, Pandey H, Shields C. Identifying teeth and tooth fragments from digital 3D models. Morphologie 2024;108(362):100774, http://dx.doi.org/10.1016/j.morpho.2024.100774.
[7] Soni S, Shirpure P, Shahu U, Johnson A. Assessment of knowledge, attitude, and practice in forensic dental anatomy and histology among dental practitioners. J Forensic Sci Med 2020;6(3):89—92 [https://journals.lww.com/jfsm/fulltext/2020/06030/assessment_of_knowledge_attitude_and_practice_in.2.aspx].
[8] Cameron JM, Sims BG. Forensic dentistry. London, UK: Churchill Livingstone; 1974 [https://books.google.co.uk/books?id=tPJpAAAAMAAJ].
[9] Kaidonis JA, Ranjitkar S, Lekkas D, Brook AH, Townsend GC. Functional dental occlusion: an anthropological perspective and implications for practice. Aust Dent J 2014;59(s1):162—73, http://dx.doi.org/10.1111/adj.12133.
[10] Kivanç B. Dental anatomy. Rijeka: IntechOpen; 2018.
[11] Schroeter C. Practical application of tooth morphology. J Prosthet Dent 1959;9(5):867—73, http://dx.doi.org/10.1016/0022-3913(59)90053-8.
[12] Nelson SJ. Wheeler's dental anatomy, physiology and occlusion: Wheeler's dental anatomy, physiology and occlusion — E-Book. Missouri, USA: Elsevier Health Sciences; 2019 [https://books.google.co.uk/books?id=KEC9DwAAQBAJ].
[13] Ng SY. Visualisation of dental anatomy in CBCT scans: part 1. Br Dental J 2024;237(2):109—16, http://dx.doi.org/10.1038/s41415-024-7568-4.
[14] Rajan S, Chen HY, Chen JJ, Chin-You S, Chee S, Chrun R, et al. Final year dental students' self-assessed confidence in general dentistry. Eur J Dent Educ 2020;24(2):233—42, http://dx.doi.org/10.1111/eje.12489.
[15] Gilmour ASM, Welply A, Cowpe JG, Bullock AD, Jones RJ. The undergraduate preparation of dentists: confidence levels of final year dental students at the School of Dentistry in Cardiff. Br Dent J 2016;221(6):349—54, http://dx.doi.org/10.1038/sj.bdj.2016.686.
[16] Hattar S, AlHadidi A, Altarawneh S, Hamdan AAS, Shaini FJ, Wahab FK. Dental students' experience and perceived confidence level in different restorative procedures. Eur J Dent Educ 2021;25(1):207—14, http://dx.doi.org/10.1111/eje.12592.
[17] Fine P, Leung A, Bentall C, Louca C. The impact of confidence on clinical dental practice. Eur J Dent Educ 2019;23(2):159—67, http://dx.doi.org/10.1111/eje.12415.
[18] Suh E, Karl E, Ramaswamy V, Kim-Berman H. The effectiveness of a 3D virtual tooth identification test as an assessment tool for a dental anatomy course. Eur J Dent Educ 2022;26(2):232—8, http://dx.doi.org/10.1111/eje.12691.
[19] Sun W, Chen H, Zhong Y, Zhang W, Chu F, Li L, et al. Three-dimensional tooth models with pulp cavity enhance dental anatomy education. Anat Sci Educ 2022;15(3):566—75, http://dx.doi.org/10.1002/ase.2085.
[20] Chaulagain R. Knowledge, attitude and practice of tooth morphology among the dentists of Kathmandu. J Nepalese Prosthodont Soc 2019;2(1).
[21] Buck D, Newton T. Continuing professional development amongst dental practitioners in the United Kingdom: how far are we from lifelong learning targets? Eur J Dental Educ 2002;6(1):36—9, http://dx.doi.org/10.1046/j.1396-5883.2001.00248.x.
[22] Bailey S, Bullock A, Cowpe J, Barnes E, Thomas H, Thomas R, et al. Core continuing professional development (CPD) topics for the European dentist. Eur J Dent Educ 2013;17(s1):23—8, http://dx.doi.org/10.1111/eje.12047.

[23] Nelson SJ. Wheeler's dental anatomy, physiology and occlusion — E-Book: Wheeler's dental anatomy, physiology and occlusion — E-Book. Missouri, USA: Elsevier Health Sciences; 2014 [https://books.google.co.uk/books?id=BM5sBQAAQBAJ].
[24] Clark DH. Practical forensic odontology. Med Legal J 1993;61(2):114, http://dx.doi.org/10.1177/002581729306100208.
[25] Aoki S, Ito T. A cognitive psychological approach for tooth identification based on brain event-related potentials. J Oral Biosci 2022;64(3):303—11, http://dx.doi.org/10.1016/j.job.2022.04.002.
[26] Wang L, Mao J, Hu Y, Sheng W. Tooth identification based on teeth structure feature. Syst Sci Control Eng 2020;8(1):521—33, http://dx.doi.org/10.1080/21642583.2020.1825238.
[27] Sorg MH, Haglund WD. Forensic taphonomy: the postmortem fate of human remains. Florida: Taylor & Francis; 1996 [https://books.google.co.uk/books?id=oNsbKIeZpcQC].
[28] de Boer HH, Roberts J, Delabarde T, Mundorff AZ, Blau S. Disaster victim identification operations with fragmented, burnt, or commingled remains: experience-based recommendations. Forensic Sci Res 2020;5(3):191—201, http://dx.doi.org/10.1080/20961790.2020.1751385.
[29] Skinner M, Alempijevic D, Stanojevic A. In the absence of dental records, do we need forensic odontologists at mass grave sites? Forensic Sci Int 2010;201(1):22—6, http://dx.doi.org/10.1016/j.forsciint.2010.03.012.
[30] Risnes S, Khan Q, Hadler-Olsen E, Sehic A. Tooth identification puzzle: a method of teaching and learning tooth morphology. Eur J Dent Educ 2019;23(1):62—7, http://dx.doi.org/10.1111/eje.12403.
[31] Mahrous A, Elgreatly A, Qian F, Schneider GB. A comparison of pre-clinical instructional technologies: natural teeth, 3D models, 3D printing, and augmented reality. J Dent Educ 2021;85(11):1795—801, http://dx.doi.org/10.1002/jdd.12736.
[32] Decurcio DA, Lim E, Chaves GS, Nagendrababu V, Estrela C, Rossi-Fedele G. Pre-clinical endodontic education outcomes between artificial versus extracted natural teeth: a systematic review. Int Endodontic J 2019;52(8):1153—61, http://dx.doi.org/10.1111/iej.13116.
[33] Alvesalo L, Tigerstedt PMA. Heritabilities of human tooth dimensions. Hereditas 1974;77(2):311—8, http://dx.doi.org/10.1111/j.1601-5223.1974.tb00943.x.
[34] Lundström A. Variation of tooth size in the etiology of malocclusion. Am J Orthod 1955;41(11):872—6, http://dx.doi.org/10.1016/0002-9416(55)90190-1.
[35] Melgaço CA, Araújo MT, Ruellas ACO. Applicability of three tooth size prediction methods for white Brazilians. Angle Orthod 2006;76(4):644—9 [https://doi.org/10.1043/0003-3219(2006)076[0644:Aottsp]2.0.Co;2].
[36] Agurto-S P, Nicholson C, del Sol M. Proposal of anatomical terms for alterations in tooth size: microdontia and macrodontia. Int J Morphol 2019;37:375—8 [http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0717-95022019000100375&nrm=iso].
[37] Erolin C. Interactive 3D digital models for anatomy and medical education. In: Rea P.M., editor. Biomedical visualisation: Volume 2. Springer International Publishing Germany; 2019. p. 1—16. [https://doi.org/10.1007/978-3-030-14227-8_1].
[38] Rodd HD, Farman M, Albadri S, Mackie IC. Undergraduate experience and self-assessed confidence in paediatric dentistry: comparison of three UK dental schools. Br Dent J 2010;208(5):221—5, http://dx.doi.org/10.1038/sj.bdj.2010.207.
[39] Loera G, Nakamoto J, Boal AL, Wendt SJ, Beck C, Cherry C. Growth in career academy students' experience, knowledge, and self-confidence related to health care careers. Career Tech Educ Res 2016;41(1):13—31, http://dx.doi.org/10.5328/cter41.1.13.
[40] Gaboutchian AV, Knyaz VA, Korost DV. New approach to dental morphometric research based on 3D imaging techniques. J Imaging 2021;7(9):1—20, http://dx.doi.org/10.3390/jimaging7090184.
[41] Milheiro A, De Tobel J, Capitaneanu C, Shaheen E, Fieuws S, Thevissen P. Quantifying the potential of morphological parameters for human dental identification: part 1-proof of concept. Int J Legal Med 2024;138(1):25—34, http://dx.doi.org/10.1007/s00414-022-02853-7.
[42] Kaidonis JA. Tooth wear: the view of the anthropologist. Clin Oral Invest 2008;12(1):21—6, http://dx.doi.org/10.1007/s00784-007-0154-8.
[43] Scott GR, Irish JD. Human tooth crown and root morphology: the Arizona State University Dental Anthropology System. United Kingdom: Cambridge University Press; 2017 [https://doi.org/10.1017/9781316156629].